Equatorial deep jets in the Atlantic Ocean

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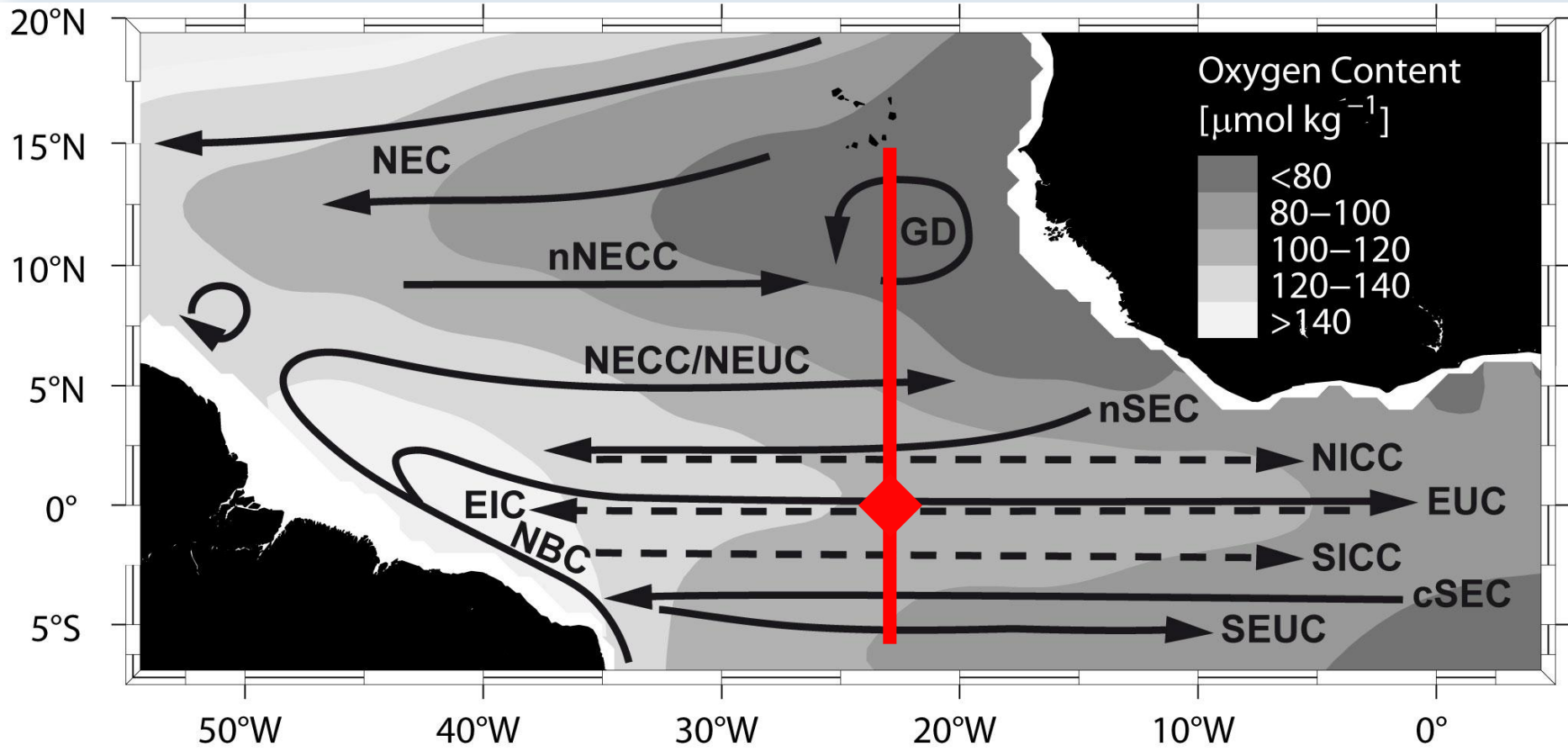
Mean Circulation and Oxygen Distribution

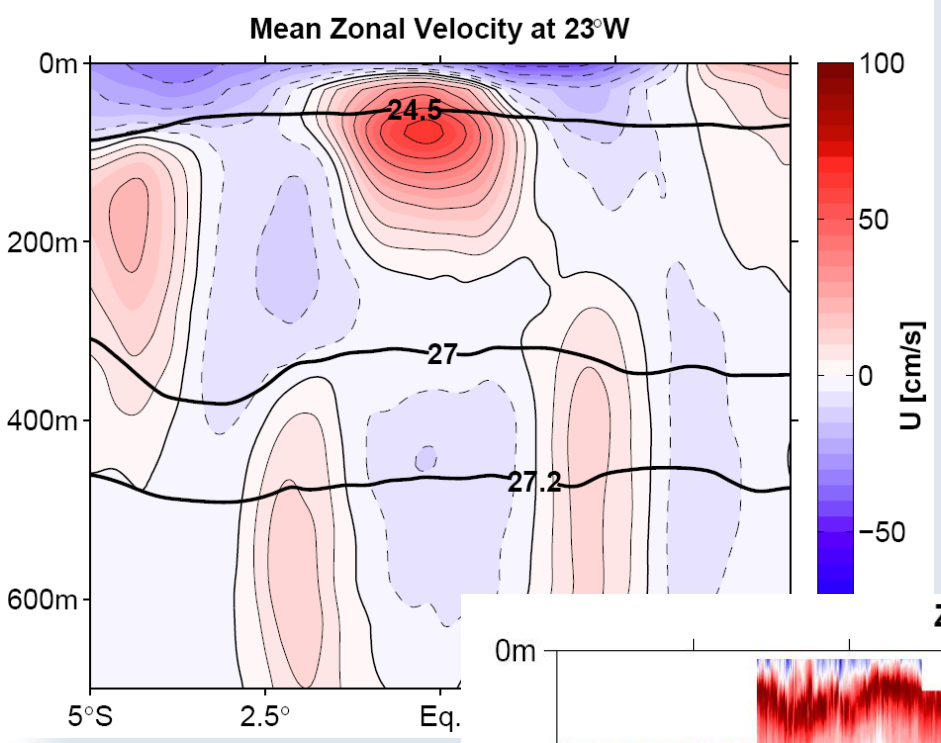
SFB 754

Complex zonal current system connects high-O_2 western boundary regime with sluggish flow in the eastern basin.

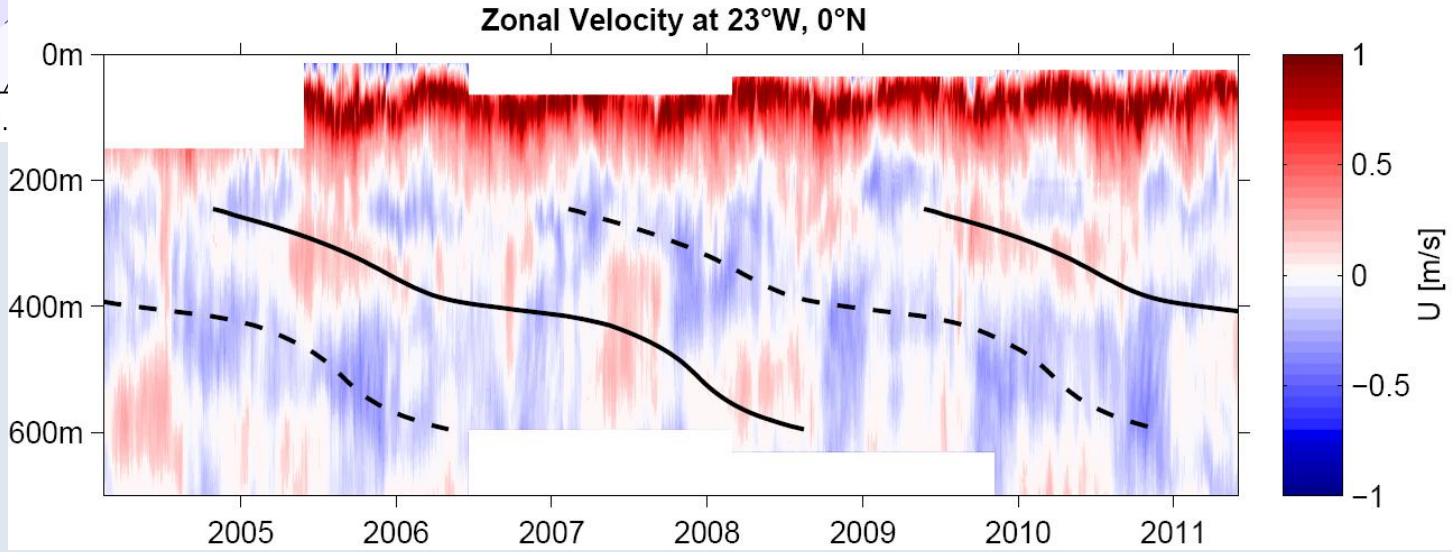


Brandt et al. 2008, 2010

Mean Zonal Velocity along 23°W and Equtorial Time Series



- NICC/SICC at 2°N/S supplies oxygen to the eastern Atlantic (e.g. Stramma et al. 2005)
- Strong mean westward flow at the equator below 380 m
- Equatoial Deep Jets with downward phase propagation



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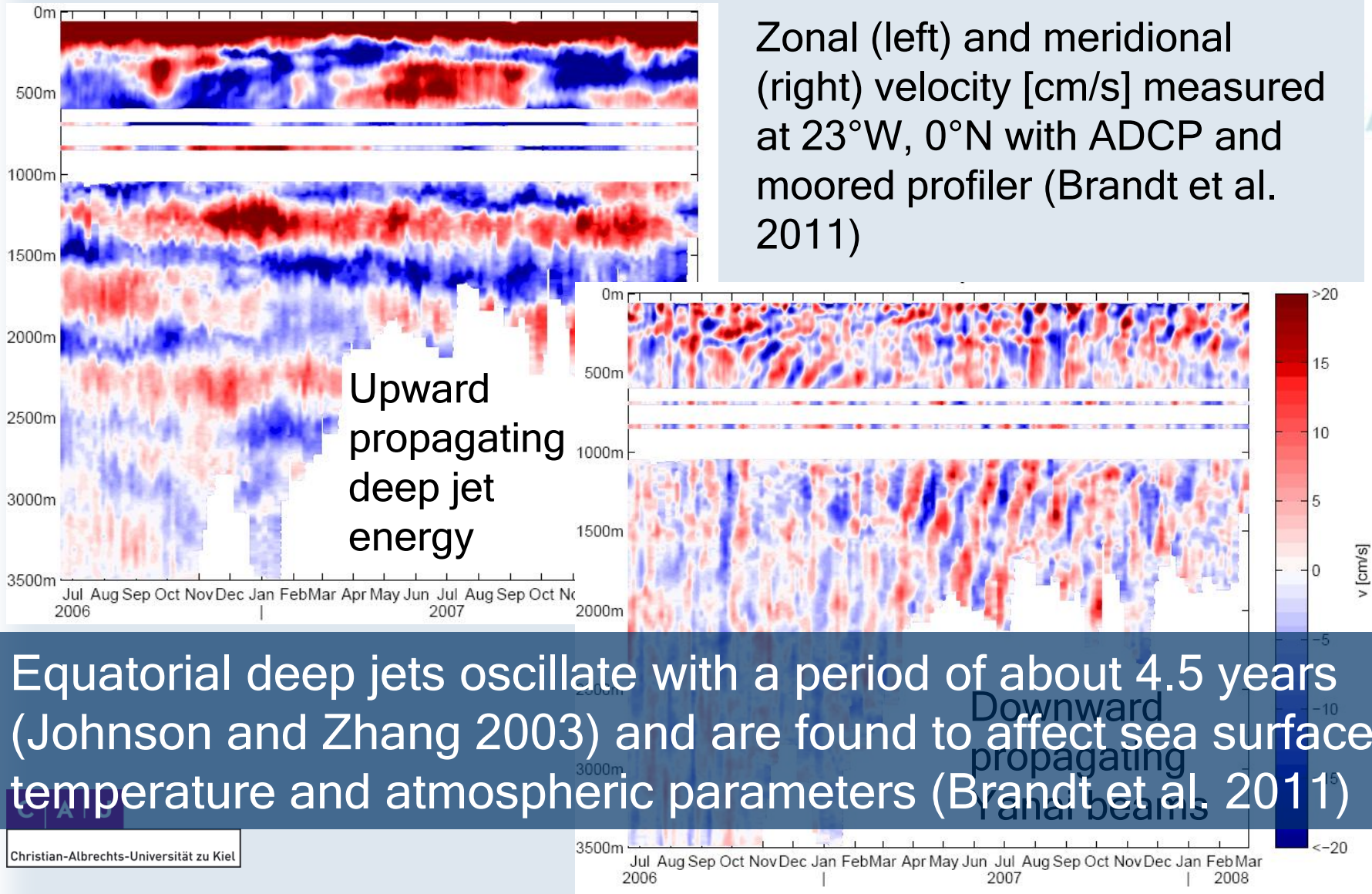
Moored Velocity Observations at the Equator, 23°W

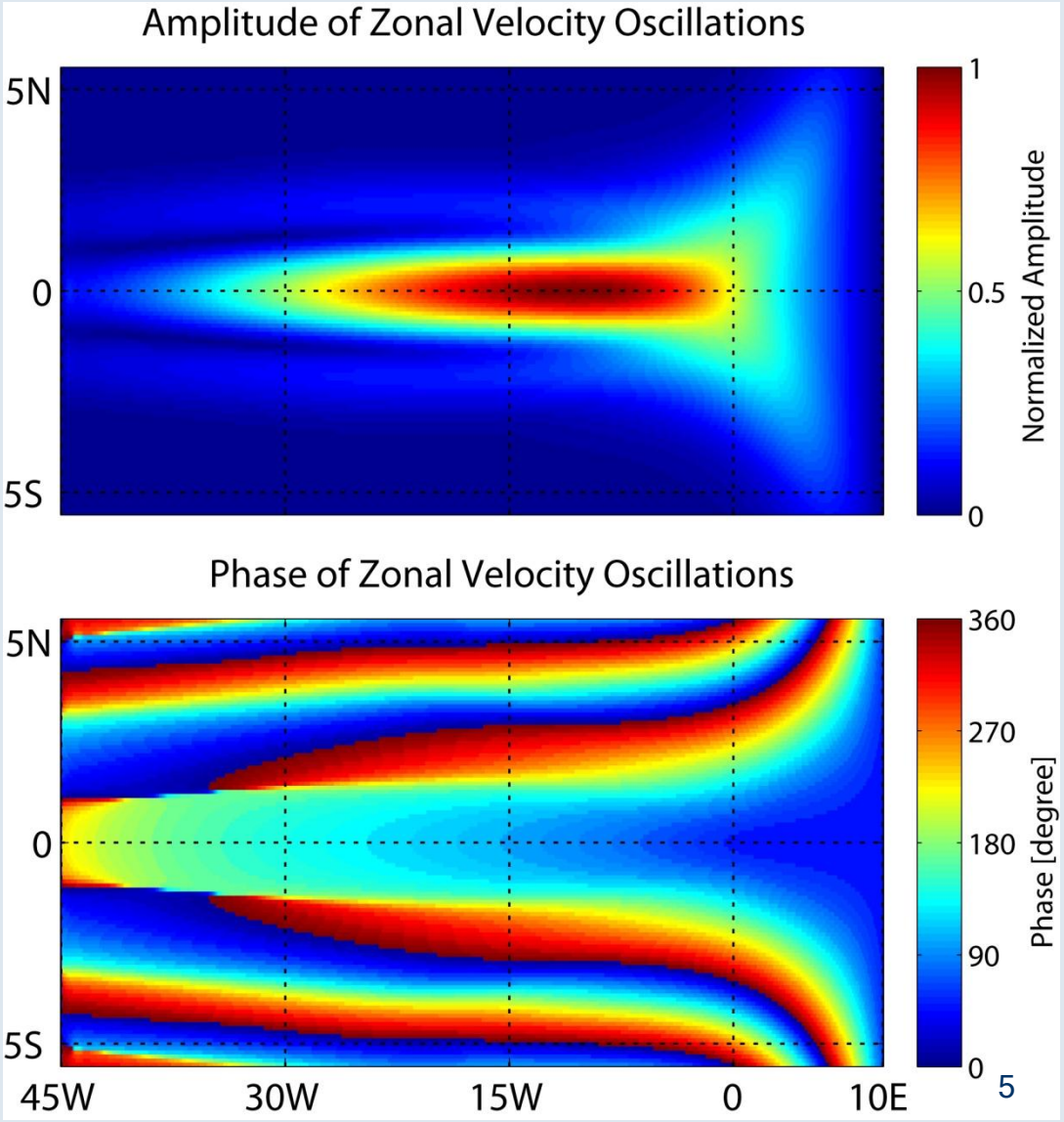


Zonal (left) and meridional (right) velocity [cm/s] measured at 23°W, 0°N with ADCP and moored profiler (Brandt et al. 2011)

Equatorial deep jets oscillate with a period of about 4.5 years (Johnson and Zhang 2003) and are found to affect sea surface temperature and atmospheric parameters (Brandt et al. 2011)

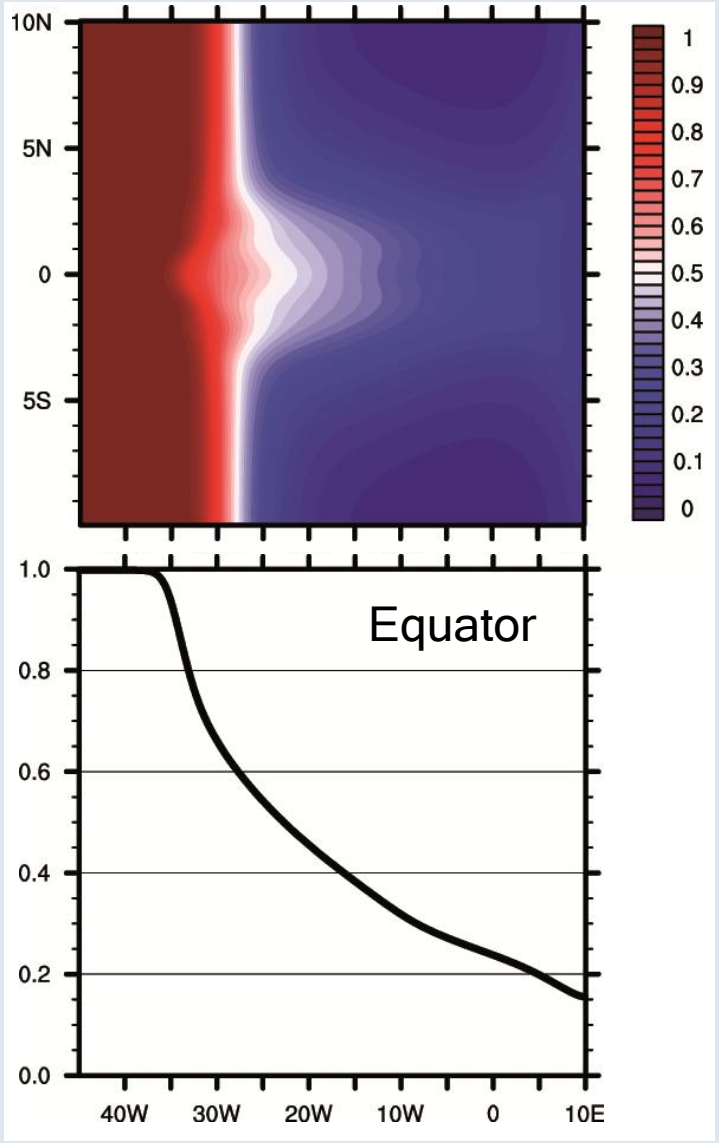
Equatorial Basin Mode

- Greatbatch et al. (2012) used a reduced-gravity model to simulate regular high-baroclinic-mode oscillations with a period of 4.5 years
- Width of the EDJs could be correctly simulated by including lateral eddy viscosity of about 200-300 m^2/s



Advection-Diffusion Model

- Model is forced by the velocity field of the equatorial basin mode
- It includes a restoring to high O_2 concentrations within the western boundary layer and O_2 consumption (van Geen et al. 2006)
- Simulation are performed until a constantly oscillating state is reached (about 160 yr)
- Mean relative O_2 concentration shows ventilation of the equatorial band due to basin mode oscillations



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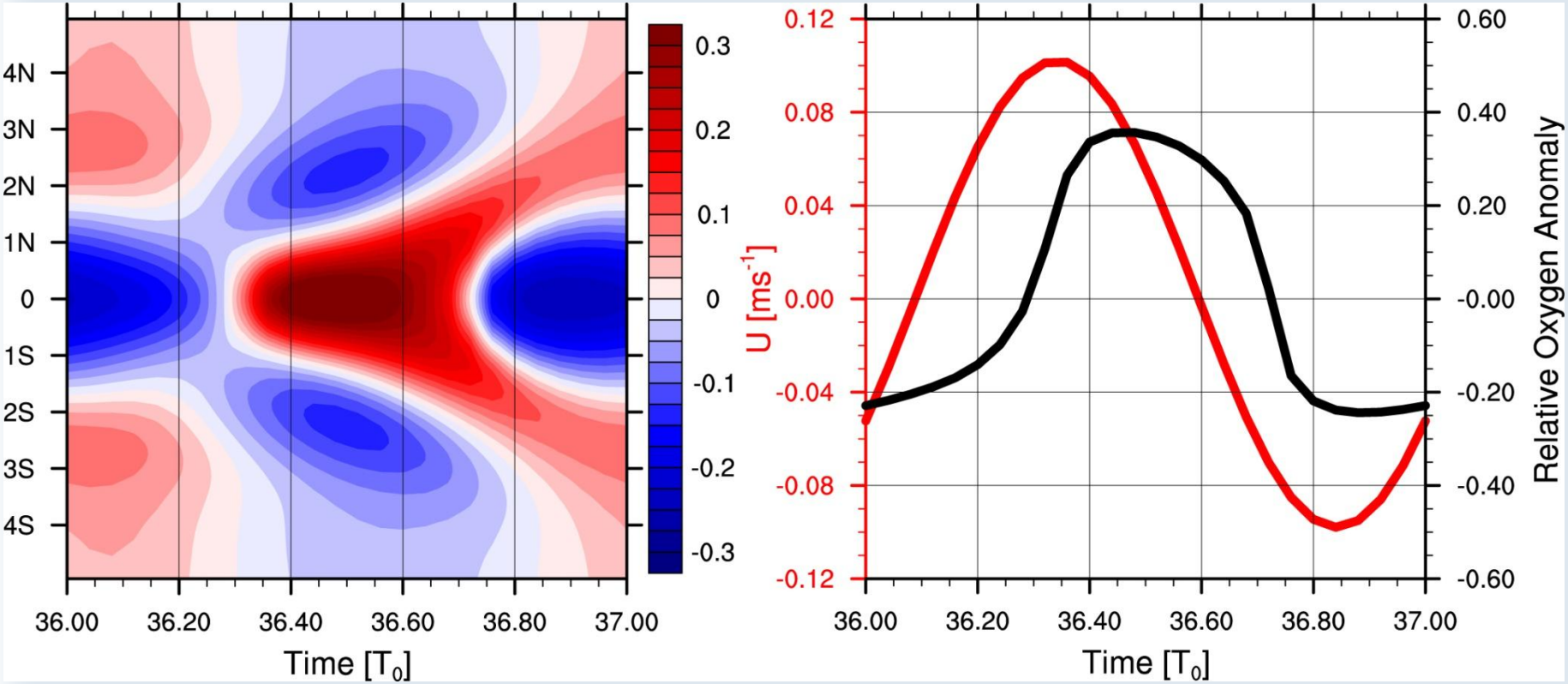
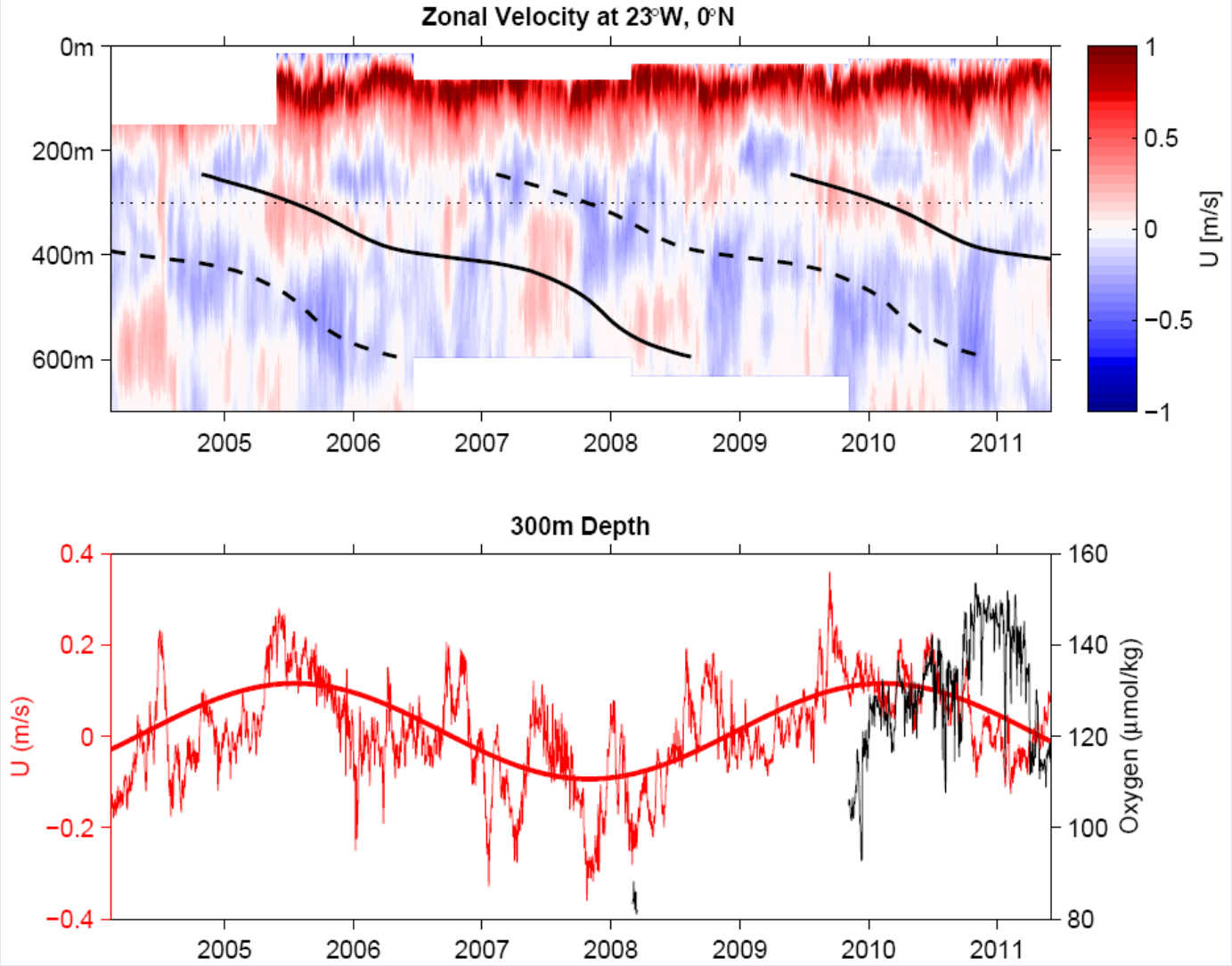
Simulated Relative Oxygen Concentration at 23°W

- O_2 oscillates with the basin mode period (T_0 = 4.5 yr) having amplitudes of about 25% of western boundary O_2 values
- Maximum O_2 concentration occurs after maximum eastward velocity (not in quadrature → mean flux)



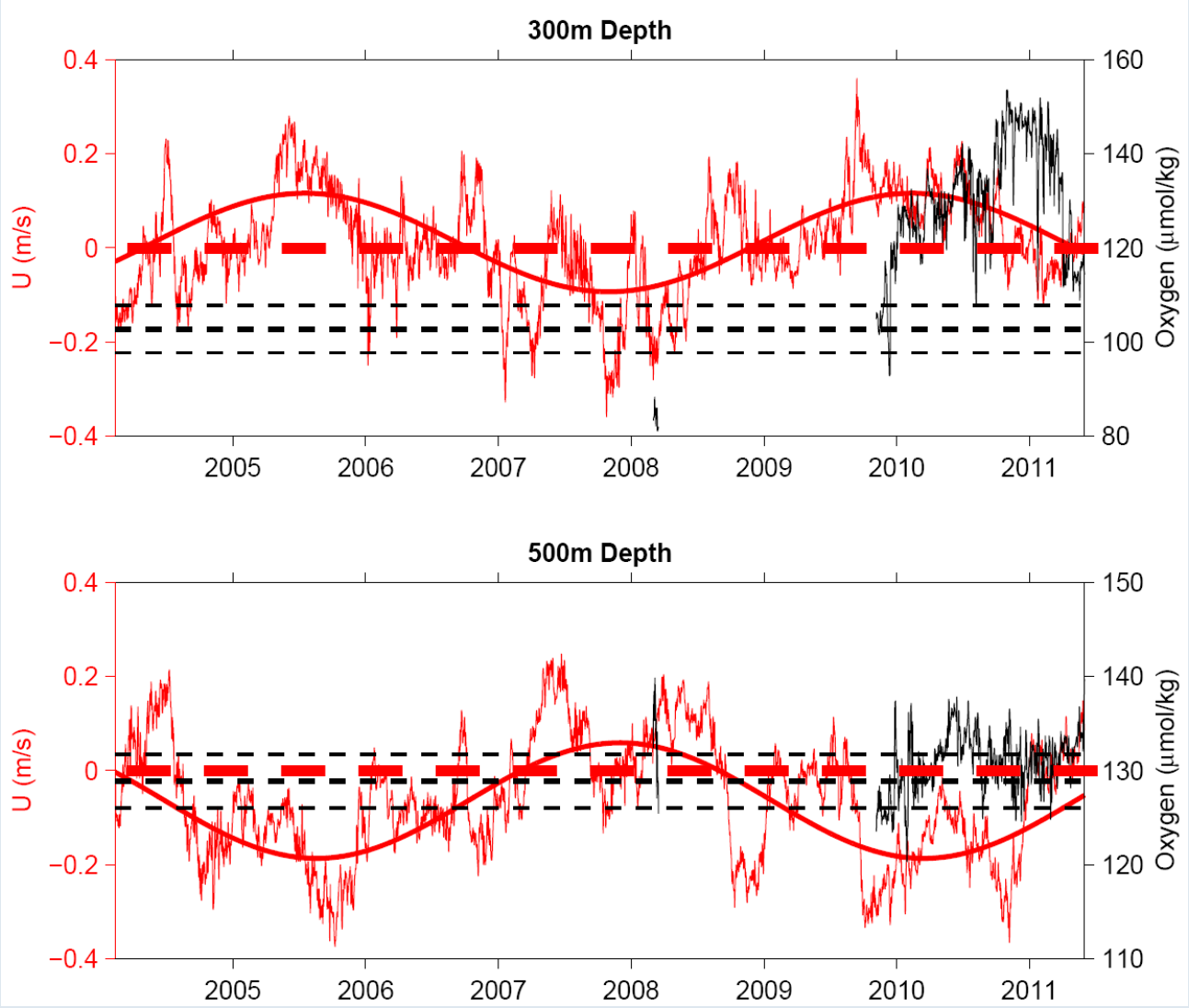
4.5-yr Deep Jet Cycle in Moored Observations at 23°W

- EDJ at intermediate depth with amplitudes of about 10 cm/s
- O_2 concentration increases during phases of eastward flow



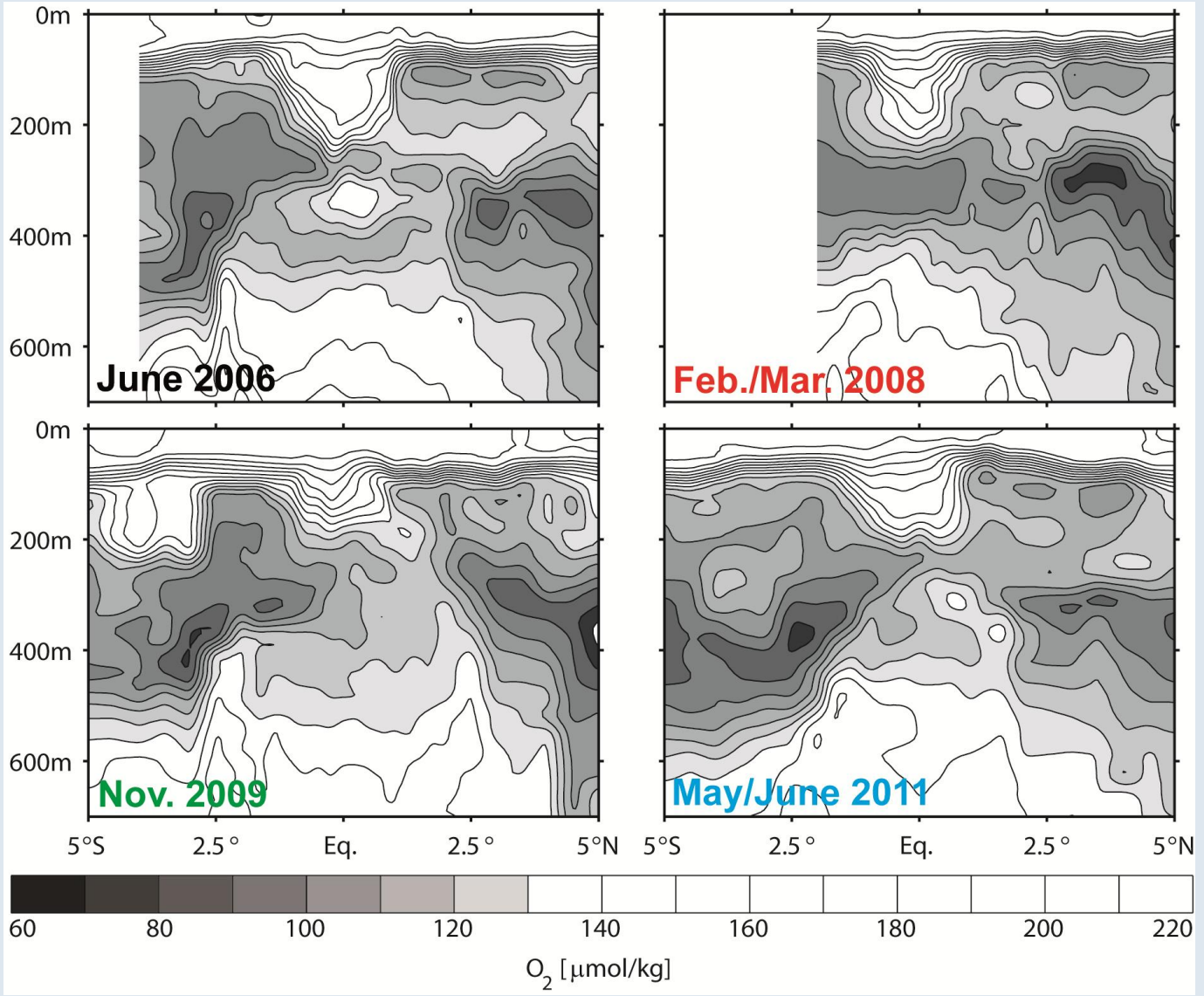
4.5-yr Deep Jet Cycle in Moored Observations at 23°W

- Low O_2 variability around mean value at 500m
- Main difference is the strong mean westward flow at 500m compared to 300m



Oxygen Distribution along 23°W from Ship Sections

- Large variability associated with different current bands
- What is the time scale of the variability?



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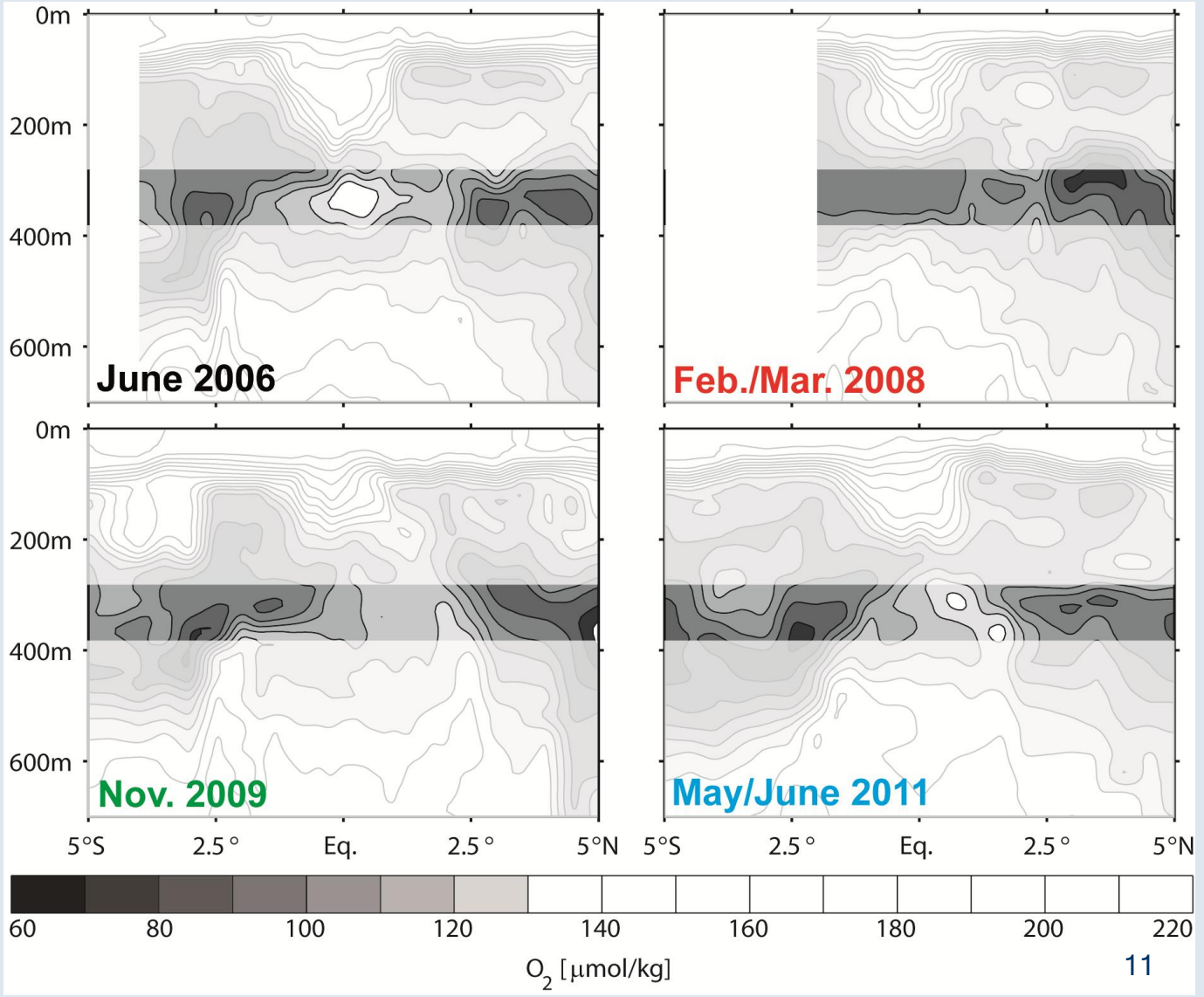
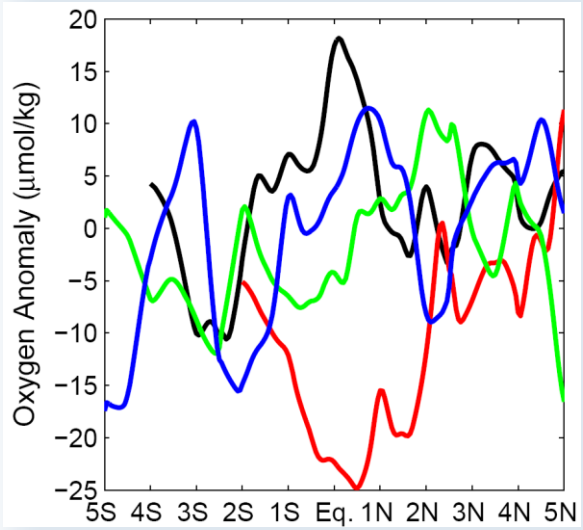
Oxygen Distribution along 23°W from Ship Sections

- Depth range 280-380m particularly strong variability
- June 2006: O_2 tongue at the equator extending from 35°W to 10°W (Brandt et al. 2008)



Meridional Oxygen Structure at 300 m

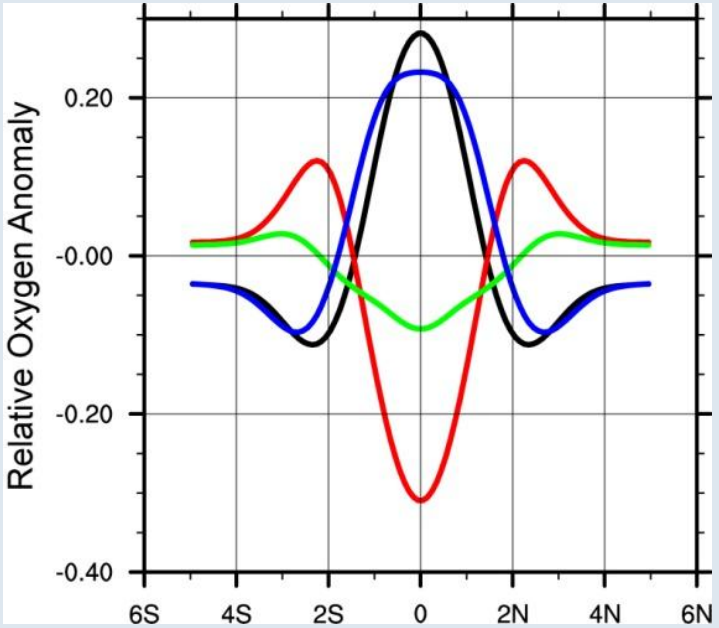
Observations↓



Simulations→

June 2006 ≙ 263 d
Feb/Mar 2008 ≙ 884 d
Nov 2009 ≙ 1505 d
May/Jun 2011 ≙ 403 d

(time of simulated structure given in days after maximum eastward velocity)



- Meridional O_2 structure is dominantly affected by EDJ
- Model is able to reproduce the general O_2 variability at the equator

Summary

Shipboard and moored observations show

- Presence of EDJ superimposed on the mean east-/westward currents (SICC, EIC, NICC)
- EDJ oscillate with a period of about 4.5 years
- Equatorial O_2 concentration is strongly affected by EDJ

Advection-diffusion model based on the equatorial basin mode explain

- Phase shift between zonal velocity and O_2 anomalies at the equator, 23°W
- Contribution of EDJ to the mean equatorial ventilation

The high-baroclinic basin mode captures several aspects of the observed Equatorial-Deep-Jet oscillations in the Atlantic

Acknowledgements

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Thank you